Changes of Chemical Properties Of Oxisols Derived from Way Kanan District as a Result of Application of Compost Made From Shells of Coffee Fruits

Supriatin

Soil Science Department, Agriculture Faculty, University of Lampung
Sumantri Brodjonegoro Street No.1 Bandarlampung 35145 Indonesia,
email: supriatin_sp@yahoo.com

Abstract

Oxisols is a heavily weathered soil that has good physical properties for planting perennial species, such as coffee and pepper. However, this soil has low nutrient availability. Way Kanan District in Lampung Province is one of the central of coffee and pepper productions in Indonesia. In this area, the soil type is dominated by Oxisols. Use of compost made from shells of Arabica coffee fruits is one way to improve soil fertility of Oxisols. The study aimed at understanding the effects of application of compost made from shells of coffee fruits to the chemical properties of Oxisols, i.e. pH, organic C content, total N, available P, and exchangeable-Ca, -K, and -Mg. An incubation experiment was conducted using a completely randomized design with four treatments and three replicates. The treatments were dosages of compost made from shells of coffee fruits i.e. 0, 5, 10, and 20 ton ha^{-1}. Each treatment was incubated during 5, 10, and 15 weeks. The results showed that application of compost made from shells of coffee fruits did not increase organic C content, total N, and available P of Oxisols during different incubation periods (i.e. after 5, 10, and 15 weeks). However, application of the compost significantly increased pH and exchangeable-K, -Ca, and –Mg of Oxisols ($P>0.05$). The highest pH and exchangeable-K, -Ca, and –Mg were found after application 20 ton ha^{-1} of compost after 5, 10, and 15 weeks of incubations. The results suggest that application of compost made from shells of Arabica coffee fruits is a potential alternative to improve fertility of Oxisols.

Key words: Soil chemical properties, compost of shells of coffee fruits, Oxisols

Introduction

Way Kanan District is known as one of the central of coffee and pepper productions in Lampung Province, Indonesia. In this area, pepper is known as primary agricultural product and coffee as secondary agricultural product. In Way Kanan District, grafted Arabica coffee and pepper are usually planted in one land, which is called a mixing cropping system. The farmers chose grafted Arabica coffee since the appearance (width and height) of this species are smaller than the appearance of another coffee species (i.e. Robusta), thus the Arabica coffee will not shadow the pepper if both plants are planted in one land. In addition, the mixing cropping system of coffee and pepper is an alternative to control soil erosion since most of the farmers in this area always cut the weeds and do not plant cover crops on their lands.

Soil type in Way Kanan District is dominated by Oxisols. Oxisols has good physical properties, such as can be tilled easily, loose, has deep solum and well drainage (Prasetyo et al., 1998). Those properties are suitable for growing perennial species, including coffee and pepper. However, Oxisols has bad soil fertility, such as low nitrogen, phosphorus, and potassium availabilities (Prasetyo et al., 1998). Moreover, most of the farmers in Way Kanan District have been using their lands more than 10 years without fertilizer applications (organic and/or inorganic fertilizers). These conditions lead to soil fertility degradation, therefore lowers coffee and pepper productions and farmers' incomes. Evizal (2001) found that pepper plantations in Lampung Province are rarely applied with fertilizers. The farmers will apply fertilizers if there are fertilizer aid programs from local government. In addition, no cover crops planted on their plantations lead to the worst soil fertility due to soil erosion. Soil fertility will be easily degraded if soil organic matter content is not maintained (Nursyamsi, 1996). Prasetyo et al. (1998) suggest that fertility of Oxisols is influenced by organic matter added to the soil.

Use of compost made from shells of coffee fruits as an organic fertilizer is one way to improve soil fertility. Fresh organic matter or compost addition to soil can increase soil organic matter content and nutrient availability. Ali and Karim (2001) found that application of compost formulated from shells of Arabica coffee and pruning of *vetiver* leaves, *Leucaena glauca* leaves, and weeds can increase N, P, K, Ca, Mg residues in soil; N and P uptakes of coffee fruits; and dry weight of coffee fruits per plant. In this study, shells of Arabica coffee fruits were chosen as a primary material for making compost due to abundant production of the shells. In Way Kanan District, the farmers have not used the shells of coffee fruits as a source of organic fertilizer. Use of compost made from shells of coffee fruits can be an alternative for farmers to get a cheap fertilizer, which is also environmentally friendly. This study was a preliminary research, which aimed at understanding the effects of application of compost made from shells of coffee fruits to the chemical properties of Oxisols, i.e. pH, organic C content, total N, available P, and exchangeable-Ca, -K, and -Mg.

Materials and Methods

Soil Sampling

Soil samples were taken from four farmers' plantations in Gunung Labuhan Sub-district, Way Kanan District, Lampung Province, Indonesia in August 2006. Criteria of the sampling areas were (1) the plantations were mixing cropping systems of grafted Arabica coffee and pepper; (2) the plantations have the same topography and environmental conditions; (3) the plantations have been used more than 10 years as mixing cropping systems of coffee and pepper without organic or inorganic fertilizer applications.

Soil samples were taken from top 0-20 cm of each plantation. For each plantation, the soil samples were taken from three randomized spots. After sampling, the soils were mixed or composited in order to get homogenous soil samples. The soil samples were air dried and passed through a 2 mm sieve.

Compost of Shells of Coffee Fruits

Compost was made by mixing shells of coffee fruits with starter materials, i.e. goat manure and weed leaves, which have low C/N ratios. The goat manure was grounded and the weed leaves was copped into 1 cm pieces. Composition of the mixture of shells of coffee fruits, goat manure, and weed biomass was 2:2:1. In order to accelerate the composting process, the mixed materials were added with the liquid containing microorganism decomposer as much as 2 L ton^{-1} total organic matter (shells of coffee fruits + goat manure + weed leaves) and sugar as much as ¼ kg ton^{-1} total organic matter (shells of coffee fruits + goat manure + weed leaves). Afterwards, the mixed materials were added with water as much as 50% of total weight of organic matter (shells of coffee fruits + goat manure + weed leaves). The mixed materials were placed in a container and incubated at room temperature during 2 weeks. During the composting process, temperature of compost was maintained at 40-50°C by mixing the compost if the temperature is above 50°C. Mixing of the compost was aim at circulating the oxygen for microorganism decomposer and releasing the heat into the air. Humidity of the compost was also maintained during the composting process by adding water if necessary. Checking the temperature and humidity of the compost was done every 5 hours.

After two weeks the compost was ready to use, which was shown by the temperature of the compost that was below 40°C or almost the same as room temperature and the compost had low C/N ratio. In addition, the compost had black color and no smell. Thereafter, the compost was passed through a 2 mm sieve in order to separate the materials that were already decomposed and the materials that were partly decomposed. Organic C, total-N, -P, -K, -Ca, and -Mg in the compost were analyzed (Table 1).

Table 1. Chemical properties of compost made from shells of Arabica coffee fruits.

Chemical properties (% dry weight)	Value*)
Organic C content (%)	20.11
Total N (%)	1.88
C/N ratio	10.70
Total P (%)	0.29
Total K (%)	4.38
Total Ca (%)	0.24
Total Mg (%)	0.09
Water content (%)	66.00

Note: Each value is the mean of two replicates.

Incubation Experiment and Soil Analyses

An incubation experiment was conducted using a completely randomized design with 4 treatments and 3 replicates. The treatments applied to the soils were dosages of compost, namely 0, 5, 10, and 20 ton ha^{-1}. Each treatment was incubated during 5, 10, and 15 weeks.

Before mixing air dried soil with compost, water content of the soil was measured using gravimetric method at 105°C. Thereafter, a 200g air dried soil (the weight was based on oven dried soil at 105°C) was mixed with compost. The amounts of compost added to the soil were 0g (~ 0 ton ha^{-1}); 2,5g (~ 5 ton ha^{-1}); 5g (~ 10 ton ha^{-1}); and 10g (~ 20 ton ha^{-1}). After that, the soil was added with deionized water up to 40% soil water content. The soils were placed in plastic bags and incubated at room temperature.

After incubation periods (5, 10, and 15 weeks), chemical properties of the soils from each treatment were analyzed, i.e. pH H_2O (electrometric method); organic C content (Walkey and Black method); total N (Kjeldahl method); available P (Bray-1 method); exchangeable-K, -Ca, and –Mg (ammonium acetate 1N pH 7 extraction method). In addition, the initial chemical properties of soils were also analyzed.

Data Analysis

In order to know the effects of the treatments (dosages of compost), data of the experiment were tested using ANOVA (Analysis of Variance). Subsequently, in order to know the differences among the treatments, the means of the treatments were tested using Least Significance Difference (LSD) test at P = 0.05.

Results and discussion

Initial Chemical Properties of Oxisols

Table 2. Initial chemical properties of Oxisols derived from the mixing cropping system of coffee and pepper in Way Kanan District, Lampung Province, Indonesia.

Chemical properties	Value*)	Criteria **)
Organic C content (%)	2.19	Moderate
Total N (%)	0.17	Low
C/N ratio	12.88	Moderate
pH H_2O (1:2.5)	4.66	Acid
Available P (mg kg^{-1})	0.11	Very low
Exchangeable K (me/100 g)	0.13	Low
Exchangeable Mg (me/100g)	0.74	Low
Exchangeable Ca (me/100g)	2.56	Low

Note: *) Each value is the mean of three replicates; **) Criteria of soil chemical properties referred to Indonesian Soil Research Institute (2005).

Initial organic C content of Oxisols derived from the mixing cropping system of coffee and pepper in Way Kanan District, Lampung Province was moderate (Table 2). Decomposition of residues of coffee and pepper (especially the leaves) resulted in an increase of organic C content of Oxisols. Grafted Arabica coffee has small appearance (width and height), but it has many leaves, which contribute a lot of residue to the soil. *Gamal* (*Gliricidia maculata*), which was used as a stand for pepper, also contributed residues to the soil. In short, a mixing cropping system of coffee and pepper is a good alternative to improve and/or maintain organic C content of Oxisols.

On the other hand, total N and exchangeable-K, -Mg, and -Ca of Oxisols were low; available P was very low and the soil pH was acid (Table 2). Those chemical properties showed that Oxisols is a heavily weathered soil; therefore, most of available N and base cations (K^+, Ca^{2+}, Mg^{2+}) were already leached from the soil. Leaching of base cations resulted in lowering the soil pH. Availability or solubility of Al^{3+} and Fe^{2+} in soil solution is relatively high (data not measured), thus those ions can bind available P and form precipitates. As a result, available P in soil solution was very low.

Chemical Properties of Oxisols after Application of Compost Made from Shells of Coffee Fruits

Table 3. Organic C content, total N, and available P of Oxisols derived from Way Kanan District after application of compost made from shells of Arabica coffee fruits.

Dosage of compost (ton ha^{-1})	Organic C (%)*			Total N (%)*			Available P (mg kg^{-1})*		
	W5	W10	W15	W5	W10	W15	W5	W10	W15
0	2.02	1.91	1.94	0.18	0.22	0.22	0.30	0.41	0.38
5	2.02	1.88	1.96	0.25	0.24	0.24	0.22	0.45	0.78
10	2.12	2.05	1.92	0.17	0.23	0.23	0.30	0.38	**
20	2.25	2.00	1.91	0.26	0.24	0.24	0.16	0.50	0.44
Analysis of Variance	ns	ns	ns	ns	ns	ns	ns	ns	-

Notes: W5 = 5 weeks of incubation; W10 = 10 weeks of incubation; W15 = 15 weeks of incubation; ns = not significant. * = each value is the mean of three replicates; ** = not measurable.

Analysis of variance showed that application of compost made from shells of Arabica coffee fruits up to 20 ton ha^{-1} did not increase organic C content, total N, and available P of Oxisols during incubation periods (i.e. after 5, 10, and 15 weeks of incubation) (Table 3). The phenomenon might be due to organic C and available N derived from compost was mostly used by soil microorganisms as source of energy for their growth. Since the initial total N of Oxisols was low (Table 2), most of available N derived from compost was taken up directly by soil microorganisms when they consumed organic C from compost added to the soil. As a result, residues of organic C and available N left in the soil were very low. No change on available P of Oxisols after compost application might be due to supply of P from the compost was relatively low. Total P in the compost used in the current study was in the same magnitude as of total P that is generally found in most compost (Hue and

Silva, 2000). Hue and Silva (2000) reported that the P content of organic fertilizers is usually relatively low. Another explanation was most of available P released from compost was fixed by iron oxides or aluminum oxides or amorphous alumino-silicate clays (Hue and Silva, 2000) contained in the Oxisols, thus become unavailable P. Organic acids produced from compost might be not sufficient to chelate aluminum- or iron- oxides that fixed P anions.

Table 4. pH and exchangeable-K of Oxisols derived from Way Kanan District after application of compost made from shells of Arabica coffee fruits.

Dosage of compost (ton ha^{-1})	pH*			Exchangeable-K (me $100g^{-1}$)*		
	W5	W10	W15	W5	W10	W15
0	4.22 (2.17) a	3.93 (2.10) a	4.00 (2.12)	0.07 (0.75) a	0.12 (0.79) a	0.09 (0.77) a
5	4.21 (2.17) a	3.92 (2.10) a	4.06 (2.14)	0.11 (0.78) a	0.18 (0.82) b	0.12 (0.79) b
10	4.24 (2.18) a	4.02 (2.13) b	4.15 (2.16)	0.15 (0.81) b	0.25 (0.87) c	0.21 (0.84) c
20	4.31 (2.19) b	4.03 (2.13) b	4.17 (2.16)	0.31 (0.90) c	0.35 (0.92) d	0.37 (0.93) d
ANOVA	s	s	ns	s	s	s
LSD, P=0.05	0.009	0.011	-	0.025	0.022	0.021

Notes: W5 = 5 weeks of incubation; W10 = 10 weeks of incubation; W15 = 15 weeks of incubation; LSD 5% = least significant difference at 5% confidence level; ANOVA = analysis of variance; s = significant; ns = not significant. * = each value is the mean of three replicates. The values with the same letter in the same column are not different after tested using LSD at P = 0.05. The values without brackets are the original data and the values in the brackets are transformed data into $\sqrt{x+0.5}$.

Application of compost made from shells of Arabica coffee fruits more than 10 ton ha^{-1} increased significantly pH of Oxisols after 5 and 10 weeks of incubations ($P < 0.05$), except after 15 weeks of incubation (Table 4). However, the increase of soil pH was only ± 0.1 units. It seems that the buffering capacity of Oxisols is relatively high, which might be related to the clay content of the soil. The increase of soil pH after compost application was due to the decrease of aluminum solubility in soil solution since organic acids produced from compost bind aluminum ions and form organic complex compounds (chelates) (Madjid, 1998 *in* Machfud, 2000; Ali, 1999). Therefore, hydrolysis of aluminum ions in soil solution, which produced H^+, can be reduced.

Application of compost made from shells of Arabica coffee fruits increased significantly exchangeable-K of Oxisols during all incubation periods (5, 10, and 15 weeks) ($P < 0.05$) (Table 4). The higher the dosage of compost added to the soil, the higher the exchangeable-K of Oxisols was. Application of compost up to 20 ton ha^{-1} increased exchangeable-K 343%; 192%; and 311% of initial exchangeable-K in control soils after 5, 10, and 15 weeks of incubations, respectively. Murbandono

(2001) suggests that compost that has good quality can contribute 90-100% of K to the soil. High contribution of compost to the exchangeable-K of Oxisols was in agreement with the high total concentration of K in the compost (Table 1). The total-K in the compost used in this study was higher than total-K in the vermicompost of coffee pulp as reported by Orozco et al. (1996).

Table 5. Exchangeable-Mg and -Ca of Oxisols derived from Way Kanan District after application of compost made from shells of Arabica coffee fruits.

Dosage of compost (ton ha^{-1})	Exchangeable-Mg (me/100g)*			Exchangeable-Ca (me/100g)*		
	W5	W10	W15	W5	W10	W15
0	0.76 (1.12)	0.81 (1.15) a	0.76 (1.12) a	2.49 (1.73)	2.51 (1.73) a	2.13 (1.62) a
5	0.73 (1.11)	0.83 (1.16) ab	0.81 (1.14) ab	2.49 (1.73)	2.64 (1.78) b	2.24 (1.65) b
10	0.81 (1.14)	0.87 (1.17) b	0.83 (1.15) ab	2.44 (1.71)	2.73 (1.80) b	2.18 (1.64) ab
20	0.83 (1.15)	0.95 (1.20) c	0.89 (1.18) b	2.65 (1.78)	2.95 (1.85) c	2.33 (1.68) c
ANOVA	ns	s	s	ns	s	s
LSD, P=0.05	-	0.025	0.035	-	0.038	0.028

Notes: W5 = 5 weeks of incubation; W10 = 10 weeks of incubation; W15 = 15 weeks of incubation; LSD 5% = least significant difference at 5% confidence level; ANOVA = analysis of variance; s = significant; ns = not significant. * = each value is the mean of three replicates. The values with the same letter in the same column are not different after tested using LSD at P = 0.05. The values without brackets are the original data and the values in the brackets are transformed data into $\sqrt{x+0.5}$.

After 5 weeks of application of the compost, exchangeable-Ca and -Mg of Oxisols did not increase significantly (Table 5). Exchangeable-Ca and -Mg of Oxisols increased significantly after 10 and 15 weeks application of the compost ($P < 0.05$). The highest exchangeable-Ca and –Mg were found after application 20 ton ha^{-1} compost to the soil (Table 5). The increases of exchangeable-Mg in this treatment were each 17% of exchangeable-Mg in control soils after 10 and 15 weeks of incubation, respectively; whereas the increases of exchangeable-Ca were 18% and 9% of exchangeable-Ca in control soils after 10 and 15 weeks of incubation, respectively. Little increases of exchangeable-Mg and –Ca of Oxisols after applications of compost were due to the fact that the compost contained lower total-Ca and –Mg compared to total-K (Table 1). The total- Mg in the compost used in this study has the same range as the total-Mg in the vermicompost of coffee pulp as reported by Orozco et al. (1996). However, the total-Ca was lower than the total Ca in the vermicompost of coffee pulp studied by Orozco et al. (1996).

Results of the current study showed that application of compost made from shells of Arabica coffee fruits up to 20 ton ha^{-1} increased pH and exchangeable-K, -Ca, and –Mg of Oxisols, but did not increased organic C content, total N, and available P. It seems that quality of the compost should be improved by mixing shells of Arabica coffee fruits with other materials that contain high nutrients. In addition, incubation period of composting process should be considered in order to get good quality of compost. A further research is needed by applying higher dosages of compost of shells of Arabica coffee fruits to the Oxisols with longer periods of incubation.

Conclusions

Application of compost made from shells of Arabica coffee fruits up to 20 ton ha^{-1} during 5, 10, and 15 weeks of incubations did not increase organic C content, total N, and available P of Oxisols derived from Way Kanan, Lampung Province, Indonesia. However, application of the compost increased significantly pH and exchangeable-K, -Ca, and –Mg of Oxisols at different incubation periods. The highest pH and exchangeable-K, -Ca, and –Mg were found after application 20 ton ha^{-1} compost during 5, 10, and 15 weeks of incubations.

Acknowledgements

The research was funded by DIPA PNBP 2006 from Research Institute of University of Lampung. I would like to thank to Prof. Jamalam Lumbanraja for introducing me to the research area. I also would like to acknowledge people from Way Kanan District, Lampung Province for their helps during the soil sampling and the research.

References

Ali, S.A. 1999. Uji penggunaan kapur dan pupuk hijau pada tanah Ultisols: Evaluasi sifat fisiko-kimia. Agrista 3: 89-96.

Balai Penelitian Tanah. 2005. Petunjuk Teknis Analisis Kimia Tanah, Tanaman, Air, dan Pupuk. Balai Penelitian Tanah, Badan Penelitian dan Pengembangan Pertanian, Departemen Pertanian, Indonesia. 143 hlm.

Evizal, R. 2001. Pola budidaya lada sistem panjatan hidup di Provinsi Lampung. J. Agrotop. 5: 14-19.

Hue, N.V. and J.A. Silva. 2000. Organic soil amendments for sustainable agriculture: Organic sources of nitrogen, phosphorus, and potassium. ***In*** J.A. Silva and R. Uchida (eds). Plant Nutrient Management in Hawaii's Soils, Approcahes for Tropical and Subtropical Agriculture, p. 133-144. College of Tropical Agriculture and Human Resources, University of Hawaii, Manoa.

Karim, A. dan S.A. Ali. 2001. Aplikasi pupuk organik hasil formulasi dari bahan baku sumber lokal terhadap hasil kopi Arabika organik di Aceh Tengah. J. Tanah Trop. 12: 93-99.

Machfud, Y. 2000. Penekanan kandungan aluminum tanah Podsolik dengan pemberian bahan organik kotoran sapi. J. Agrikultura 11: 143-148.

Murbandono, L. 2001. Membuat Kompos (Edisi Revisi). Penebar Swadaya. Jakarta. 54 hlm.

Nursyamsi, D., J.S. Adiningsih, Sholeh, dan A. Adi. 1996. Penggunaan bahan organik untuk meningkatkan efisiensi pupuk N dan produktivitas tanah Ultisols di Sitiung, Sumbar. J. Tanah Trop. 2: 26-33.

Orozco, F.H., J. Cegarra, L.M. Trujillo, and A. Roig. 1996. Vermicompost of coffee pulp using the earthworm *Eisenia fetida*: Effects on C and N contents and the availability of nutrients. Biol. Fertil. Soils. 22: 162-166.

Prasetyo, B.H., B. Kaslan, dan S. Ritung. 1998. Oxisols di daerah Lampung Utara: komposis mineral, sifat kimia, dan klasifikasinya. J. Tanah Trop. 6: 153-164.

Proceeding

3rd INTERNATIONAL CONFERENCE FOR DEVELOPMENT OF IPM IN ASIA AND AFRICA
Marcopolo Hotel
7th – 9th December 2009

Development of Integrated Pest Management in Asia and Africa

Volume 3

Edited by:

Jamalam Lumbanraja
F.X. Susilo
Purnomo
Rosma Hasibuan
Ainin Niswati
Sri Yusnaini
Hidetaka Hori
Keiichi Okazaki

Published by the University of Lampung Press
ISBN: 978-602-8616-33-1

Changes of Chemical Properties Of Oxisols Derived from Way Kanan District as a Result of Application of Compost Made From Shells of Coffee Fruits

Supriatin

Soil Science Department, Agriculture Faculty, University of Lampung
Sumantri Brodjonegoro Street No.1 Bandarlampung 35145 Indonesia,
email: supriatin_sp@yahoo.com

Abstract

Oxisols is a heavily weathered soil that has good physical properties for planting perennial species, such as coffee and pepper. However, this soil has low nutrient availability. Way Kanan District in Lampung Province is one of the central of coffee and pepper productions in Indonesia. In this area, the soil type is dominated by Oxisols. Use of compost made from shells of Arabica coffee fruits is one way to improve soil fertility of Oxisols. The study aimed at understanding the effects of application of compost made from shells of coffee fruits to the chemical properties of Oxisols, i.e. pH, organic C content, total N, available P, and exchangeable-Ca, -K, and -Mg. An incubation experiment was conducted using a completely randomized design with four treatments and three replicates. The treatments were dosages of compost made from shells of coffee fruits i.e. 0, 5, 10, and 20 ton ha^{-1}. Each treatment was incubated during 5, 10, and 15 weeks. The results showed that application of compost made from shells of coffee fruits did not increase organic C content, total N, and available P of Oxisols during different incubation periods (i.e. after 5, 10, and 15 weeks). However, application of the compost significantly increased pH and exchangeable-K, -Ca, and –Mg of Oxisols ($P>0.05$). The highest pH and exchangeable-K, -Ca, and –Mg were found after application 20 ton ha^{-1} of compost after 5, 10, and 15 weeks of incubations. The results suggest that application of compost made from shells of Arabica coffee fruits is a potential alternative to improve fertility of Oxisols.

ey words: Soil chemical properties, compost of shells of coffee fruits, Oxisols

Introduction

Way Kanan District is known as one of the central of coffee and pepper roductions in Lampung Province, Indonesia. In this area, pepper is known as rimary agricultural product and coffee as secondary agricultural product. In Way anan District, grafted Arabica coffee and pepper are usually planted in one land, hich is called a mixing cropping system. The farmers chose grafted Arabica coffee nce the appearance (width and height) of this species are smaller than the ppearance of another coffee species (i.e. Robusta), thus the Arabica coffee will not ıadow the pepper if both plants are planted in one land. In addition, the mixing opping system of coffee and pepper is an alternative to control soil erosion since